9.—Prehistoric mammal faunas from two small caves in the extreme south-west of Western Australia

by M. Archer* and A. Baynes**

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Abstract

Mammal faunas are reported from deposits in two small caves near Augusta, Western Australia. They are considered to have been acmulated by owls. Identifications by previous authors are discussed for certain species. The faunas are compared with previous records of both modern and fossil populations of each species in the area. A radiocarbon date (GaK-2949) of 430 $\pm$ 160 years B. P. is reported for hair from the larger deposit, and the ages of both deposits are discussed. The youngest known fossil *Sarcophilus* specimen from the Australian mainland is reported. The first record of *Rattus tunneyi* in the extreme south-west is discussed, and it is concluded that the species extended its range into the area in the last 8,000 years. It is suggested that it reached the area via west coastal heath habitats, from the Swan coastal plain.

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Introduction

In 1968 our attention was drawn by Mr P. R. Lake to mammal bones (Western Australian Museum 67.8.5) which he had collected from small pockets in the vertical aeolian limestone face of the cliffs (Fig. 1) along the east side of Turner Brook, near Augusta in the Cape Leeuwin-Cape Naturaliste region of south-western Australia. Two of the pockets contained interesting animal remains, and results of work on these are reported in this paper. Because the pockets are too small to merit names they are referred to throughout as Cave 1 and Cave 3. They are registered as Au24 and Au25 respectively by the Western Australian Speleological Group (Mr P. J. Bridge, pers. comm.).

The vegetation in the valley adjacent to the cliffs is peppermint woodland (see Fig. 1). On

Figure 1.—The cliffs on the east side of Turner Brook. They rise to a height of 60 m.

the higher ground this is replaced by shrubby heath. To the south the woodland gives way to heath and then mobile sand dunes near the sea shore which is about 1 km south of the caves.

The geological nature of the cliffs and these pockets is not clearly understood. The calcareous aeolianite, of which the cliff is composed, is generally assumed to be Quaternary in age and to represent consolidated calcareous dune sands which have a coastal origin (Jennings 1968). There are no absolute dates available for the particular dune in which the cliffs occur. Jennings (1968) and Bain (1962) discuss the history of the cliffs and Jennings (1968) concludes that they may have been produced as a consequence of removal by Turner Brook of the mobile dune sands that settled across its course. He suggests that vigorous stream activity resulted in a steep dune face along the east bank of the stream valley, as well as a smaller dune face along the west bank. However this interpretation is complicated by our finding, near the base of the cliffs, what appear to be rounded heads of granite cobbles that resemble coastal cobble beds present and possibly forming along the beach a few miles north of Turner Brook. Further, from the loose sediments along Turner Brook in the vicinity of the cliffs we recovered fragments of marine echinoids, bryozoans, molluscs and benthic foramina. These observations suggest that the cliffs might be sea cliffs resulting from a previous high stand of sea level. The ceilings of at least some of the small pockets in the cliff face are composed of what appears to be cemented limestone rubble, rather than simple bedded aeolianite. Similar rubble occurs in several south-west caves such as Mammoth Cave. It is therefore possible that the cliffs and their small limestone pockets may have had a different origin than that suggested by Jennings (1968).

The morphology of Cave 1 is typical of several pockets at various heights and positions along the face of the cliff. It is a wedge-shaped impression in the cliff face whose floor slopes steeply up and back into the cliff face to meet the ceiling at the rear of the pocket. There are many small horizontal solution cavities connected to the pocket. Bones occur in these small solution cavities as well as on the floor of the pocket itself. Cave 3 is a similar but much smaller pocket about 100 m upstream from Cave 1 and about 4 m vertically above the base of the cliff.

The bone-bearing deposit in Cave 1 is probably over 10 cm thick, and appears to have filled a natural depression in the floor of a horizontal solution cavity in the cave. Near the surface, the bone is abundant and there is relatively little limestone rubble. Below 8 cm the proportion of limestone rubble increases rapidly. At about 10 cm the limestone rubble comprises almost all of the deposit and at this depth there are numerous spaces into which material has fallen from higher levels. For this reason we concerned ourselves with only the upper 8 cm of the Cave 1 deposit. The Cave 3 bone-bearing deposit had proportionately less bone and was slightly deeper. We collected a sample to a depth of 13 cm from the deposit in Cave 3.

Material was collected from the caves on three separate occasions by scooping the bone-bearing matrix into cotton specimen bags using trowels and bare hands. Bones and mammal hair were sorted from the matrix in the laboratory. After identification, estimates were obtained of the minimum number of individuals represented by counting left and right sides of skulls or dentaries etc. and treating the larger of the two figures as the minimum number of individuals. Mammal specimens were accessed in the palaeontological collection of the Western Australian Museum (71.11.199-327). Other catalogue numbers (e.g. M8351) referred to in this paper are those of the modern mammal collections of the Western Australian Museum. Cave names are used without apostrophes in accord with the policy of the Department of Lands and Surveys of Western Australia (e.g. Devil's Lair becomes Devils Lair).

Responsibility for the identification and discussion of the mammal specimens is divided between the two authors. Marsupial and bat specimens were identified by M. Archer. Murid specimens were identified by A. Baynes. The nomenclature used here is that adopted by Ride (1970). In the case of the dasyurids, the identifications are based on revisional work within the family Dasyuridae by M. Archer, to be published elsewhere. In the case of the murids, the nomenclature used by Ride (1970) is based upon the long term research of J. A. Mahoney who has identified large numbers of murid specimens which are lodged in the Western Australian Museum collections. These series are here considered to embody the concepts implied by the names used by Ride (1970) in all cases except one. The exception is *Pseudomys praeconis*. Until recently confusion existed in identifications of specimens from cave deposits of this species and the very similar *Pseudomys nanus*. However, A. Baynes has now carried out a study on the maxillae of these species (to be published elsewhere) on the basis of which they were separated. As a result it was found that most of the specimens from caves in the Moore River-Dongara region (including a series with 63.9.1 from Hastings Cave which Mahoney had tentatively identified as *P. nanus*), and all the specimens examined from the Cape Leeuwin-Cape Naturaliste region, grouped with modern specimens of *P. praeconis*. Pending further investigation they are recorded under that name. Methods of diagnosis of rodent species used by A. Baynes will be published in the form of a key to the rodents of south-western Australia.

Faunas

The species identified in the Cave 1 deposit within 8 cm of the surface, and the minimum number of individuals of each species represented are listed below:

Metatheria	
Dasyuridae:	
Sminthopsis murina	61
Antechinus flavipes	57
Phascogale tapoatafa	1
Dasyurus geoffroii	2
Sarcophilus harrisii	1
Peramelidae:	
Isoodon obesulus	7
Burramyidae:	
Cercartetus concinnus	8
Petauridae:	
Pseudocheirus peregrinus	1
Eutheria	
Vespertilionidae:	
Nyctophilus timoriensis	1
Muridae:	
Pseudomys shortridgei	140
Pseudomys praeconis	3
Rattus fuscipes	231
Rattus tunneyi	114
Rattus sp.*	26

* These do not represent a third species in this genus. They are broken or incompletely developed specimens which could not be assigned to either named species with certainty.

The exact provenance of the single premolar that represents *Sarcophilus harrisii* is not certain. It was collected from the foot of the cliff immediately below a small opening that leads back into the solution cavity in Cave 1 that contained the Cave 1 deposit. Bone material in the solution cavity was found scattered as far as this opening in the cliff face. There were other small bones lying with the *S. harrisii* tooth that resembled the material from the Cave 1 deposit. This suggests that a quantity of material including the *Sarcophilus* tooth fell from the deposit.

In addition, there are numerous passerine bird specimens represented by skeletal remains. No attempt has been made to identify them. There are also insect remains which represent eleven families and four orders (pers. comm. from Mrs E. A. Archer, Western Australian Museum) and molluscan remains which represent one genus (pers. comm. from Mr G. W. Kendrick, Western Australian Museum).

The species identified in the Cave 3 deposit within 13 cm of the surface, and the minimum number of individuals of each species are listed below:

Metatheria	
Dasyuridae:	
Sminthopsis murina	5
Antechinus flavipes	24
Phascogale tapoatafa	1
Peramelidae:	
Isoodom obesulus	2
Burramyidae:	
Cercartetus concinnus	2
Phalangeridae:	
Trichosurus vulpecula	2
Petauridae:	
Pseudocheirus peregrinus	1
Macropodidae:	
Potorous tridactylus **	1
Bettongia sp.	1
Setonix brachyurus	1
Eutheria	
Muridae:	
Pseudomys albocinereus	3
Pseudomys shortridgei	11
Pseudomys praeconis	4
Rattus fuscipes	38
Rattus tunneyi	4
Rattus sp.*	6
Hydromys chrysogaster	1

* See comment below species list for Cave 1.
** The identification is based on a worn molar and may not be correct.

In addition there are mollusc specimens representing four species of terrestial snails, one of which is an evidently undescribed prosobranch (pers. comm. from Mr G. W. Kendrick).

Species concepts

Before proceeding with a consideration of the species contained within these deposits it is necessary to examine the concepts implied by certain names used by previous authors in discussing relevant faunas. Many of the pioneering studies on cave deposit faunas in Western Australia were carried out by E. L. Lundelius (1957, 1960, 1963, 1964 and 1966). He deposited small samples of identified specimens in the Western Australian Museum. These were catalogued several years later. Generally only one specimen in each sample received a catalogue number. Most of the specimens are from Hastings Cave. Comparisons of specimens we collected from the same deposit with those attributed to Lundelius, perhaps erroneously, reveal disagreements in identification of some of the small dasyurid and murid specimens.

Lundelius (1957) states that *Sminthopsis hirtipes* is represented in cave deposits at Jurien Bay and Minnegara. However Lundelius (1960 p. 149) later qualifies this statement as follows: "Unfortunately the identification of the species *Sminthopsis* and the genus *Notomys* is very uncertain at the present time because of the imperfect knowledge of the Recent species. There are two species of *Sminthopsis* present in Drover's Cave [Hastings Cave, see Merrilees 1968]. A small species which resembles *S. hirtipes* is abundant in the surface deposits of a number of caves north of Perth. A larger species whose affinities are unknown is abundant in the lower layer and is only doubtfully identified in the top layers." In the Western Australian Museum collections there are seven "*Sminthopsis*" samples from Hastings Cave whose collection and identification is attributed on the labels to E. L. Lundelius. Re-identifications of some of the specimens in these samples given below are based on concepts developed as a result of the revisional studies of the Dasyuridae by M. Archer. One sample (including 63.6.21 and 72.4.10) is identified by Lundelius as "*Sminthopsis* sp. small". Specimen 63.6.21 represents *S. murina* and specimen 72.4.10 represents *S. granulipes* on the criteria used here. A second sample (including 63.6.22 and 72.4.11) is identified by Lundelius as "*Sminthopsis* sp. large". Specimen 63.6.22 represents *S. granulipes* and specimen 72.4.11 represents *Antechinus flavipes* on the criteria used here. A third sample (including 63.6.15 and 72.4.12) is identified by Lundelius as "*Sminthopsis hirtipes*". Specimen 63.6.15 represents *S. granulipes* and specimen 72.4.12 represents *S. murina* on the criteria used here. Two other samples (including 66.1.30-34 and 63.2.26) are identified by Lundelius as "*Sminthopsis murina*". All of these specimens appear to represent *S. granulipes* on the criteria used here. Two final samples (including 63.2.27, and 66.1.40-48) have associated labels indicating they were identified by Lundelius as "*Sminthopsis crassicaudata*". All of the numbered specimens in these samples are considered to represent *S. murina* except 66.1.41 and 66.1.45 which on the criteria used here are considered to represent *S. granulipes*. Cook (1960) states that his identification of *S. crassicaudata* from Devils Lair (= Nannup Cave of Cook 1960, see Merrilees 1968) in the Cape Leeuwin-Cape Naturaliste region was based on comparison with specimens identified as that species by E. L. Lundelius. However, Cook did not designate the specimens he used, and Lundelius' published faunal lists from western coastal cave deposits do not include *S. crassicaudata*. Cook's specimens (65.10.150-153) are considered to represent *S. murina* on the criteria used here.

Because the specimens were accessed after Lundelius published his identifications it is impossible to be certain that the specimens in these samples were among those referred to by Lundelius (1957 and 1960). However, all of the specimens representing *Sminthopsis* species subsequently collected by us from Hastings Cave are considered to represent only *S. murina* and *S. granulipes*. Further, as a result of examination of modern and fossil dasyurids, it is possible to say that these are the only species of *Sminthopsis* (as presently understood) known to have inhabited the coastal plain south of the Jurien area. These re-interpretations are important because inferences of past climates from fossil faunas by Lundelius (1960) are in part drawn from the presumed presence of the arid adapted *S. hirtipes* in the Hastings Cave deposit.

Lundelius (1957, 1960) recognizes four species of the murid genus *Pseudomys* in cave deposit faunas from the west coast of Australia: *P. shortridgei*, *P. occidentalis*, *P. albocinereus*, and *P. nanus*. The samples of specimens lodged in the Western Australian Museum, labelled identified by Lundelius as *P. shortridgei* (including 63.6.11) and *P. occidentalis* (including 63.6.12) are in accord with the concepts of these species used here. In the case of *P. albocinereus* the sample consists of three specimens (63.6.16, 72.4.13 and 72.4.14), which were collected, and apparently identified by Lundelius. Only 63.6.16 is judged to be *P. albocinereus*, 72.4.13 and 72.4.14 are considered to be juvenile *P. occidentalis* on the criteria used here. This may result from misassociation of label and specimens, as Lundelius (pers. comm.) is confident he correctly separated these species. The samples (including 63.6.20 and 70.6.28) labelled identified by Lundelius as *P. nanus* are among those indicated by the study referred to above to be probably *P. praeconis*.

Lundelius (1960) lists two species of *Rattus* in faunas from west coast cave deposits. *R. fuscipes* he considered to be present in all those he reported on, i.e. between Cape Leeuwin and Jurien Bay. In addition he recognized a second species from the more northern deposits in this region which he identified only as *Rattus* sp. He deposited in the Western Australian Museum a single sample of *Rattus* maxillae (including 63.6.19) from Hastings Cave, which the label indicates he identified as *R. fuscipes*. All six specimens in this sample are considered to be *Rattus tunneyi* on the criteria used here. Research being carried out by A. Baynes on the fauna from Hastings Cave deposit shows that *R. fuscipes* is indeed present, but the specimens are considerably smaller than both *R. tunneyi* specimens from the same deposit, and *R. fuscipes* specimens from the Cape Leeuwin-Cape Naturaliste region. As will be shown below, it is probable that the *Rattus* sample from Devils Lair examined by Lundelius (1960) included only *R. fuscipes*. Although Lundelius (1960) makes no comment on the relative sizes of the species he separates, it is possible that he identified specimens in the northern deposits as *R. fuscipes* on the basis of larger size, and placed the small (true *R. fuscipes*) specimens under *Rattus* sp. Thus in Lundelius' records from the Cape Leeuwin-Cape Naturalist region *R. fuscipes* is probably correctly identified, whereas for deposits north of Perth *Rattus* species appear to be confused.

Previous records in the region

It is useful to consider whether the species have been collected live and what their known

Table 1

The distribution of species which occur in the Cave 1 and Cave 3 faunas

	Recorded live from the region	Cave 1	Cave 3	Devils Lair	Pleistocene deposit in Mammoth Cave
Sminthopsis murina	+	+	+	+	+
Antechinus flavipes	—	+	+	+	+
Phascogale tapoatafa	+	+	+	+	+
Dasyurus geoffroii	+	+	—	+	—
Sarcophilus harrisii	—	+	—	+	—
Isoodon obesulus	+	+	+	+	—
Cercartetus concinnus	+	+	+	+	—
Trichosurus vulpecula	+	—	+	+	—
Pseudocheirus peregrinus	+	+	+	+	+
Potorous tridactylus	—	—	?	+	+
Bettongia penicillata	+	—	?	+	—
Bettongia lesueur	—	—	?	+	—
Setonix brachyurus	+		+	+	+
Nyctophilus timoriensis	—	+	—	—	—
Pseudomys albocinereus	—		+	+	—
Pseudomys shortridgei	—	+	+	+	—
Pseudomys praeconis	—	+	+	+	—
Rattus fuscipes	+	+	+	+	+
Rattus tunneyi	—	+	+	—	—
Hydromys chrysogaster	+		+	—	—

\+ = present.
— = absent.

fossil record is in the Cape Leeuwin-Cape Naturaliste region. This information is summarized in Table 1.

There are only two relevant dated bone-bearing deposits in this region: the Pleistocene deposit in Mammoth Cave (reviewed most recently by Merrilees 1968) and the deposit in Devils Lair (reviewed most recently by Dortch and Merrilees 1972). The ages of these deposits are discussed below. Other fossil faunas from this region reported by Glauert (1948), Cook (1963) and Merrilees (1968 and 1969) have not been radiometrically dated.

Sminthopsis murina was reported by Shortridge (1910) to occur live near Margaret River in the Cape Leeuwin-Cape Naturaliste region. Dortch and Merrilees (1972) recorded the species as a fossil from Devils Lair. Specimens (e.g. 68.6.286) known from the Mammoth Cave deposit are considered to represent this species.

Antechinus flavipes (e.g. M 2037) is known live from the Cape Leeuwin-Cape Naturaliste region. Cook (1963) considered a single fossil tooth from Strongs Cave possibly to represent *Antechinus flavipes.* Dortch and Merrilees (1972) report fossil *A. flavipes* from Devils Lair. Lundelius (1960) reports fossil specimens of *Antechinus ?* from Devils Lair. Specimens (e.g. 68.6.285) considered to represent *A. flavipes* are known from the Mammoth Cave deposit.

Sarcophilus harrisii has only been recorded live on the Australian mainland in Victoria, but there is some doubt about the interpretation of these records (discussed below). The species is known as a fossil from the Cape Leeuwin-Cape Naturaliste region, for example from Mammoth Cave (Merrilees 1968), Devils Lair (Lundelius 1960, Dortch and Merrilees 1972), Strongs Cave (Cook 1963), Brides Cave (Glauert 1948), and Labyrinth Cave (Merrilees 1969).

Phascogale tapoatafa, Dasyurus geoffroii, Isoodon obesulus, Trichosurus vulpecula, Pseudocheirus peregrinus, and *Setonix brachyurus* have all been collected live from the Cape Leeuwin-Cape Naturaliste region (Shortridge 1910), and all are represented by fossils from Devils Lair (Lundelius 1960, Dortch and Merrilees 1972) and Mammoth Cave (Lundelius 1960 or Merrilees 1968).

Cercartetus concinnus is represented by specimens (e.g. 10510) in the modern mammal collections of the Western Australian Museum from the Cape Leeuwin-Cape Naturaliste region. It was also evidently known to Aboriginals who inhabited the area within historic times (Shortridge 1910). It has been reported as a fossil by Cook (1963) in the Strongs Cave fauna, and by Dortch and Merrilees (1972) from Devils Lair.

Potorus tridactylus may now be extinct in the Cape Leeuwin-Cape Naturaliste region (Shortridge 1910). It has been reported as a fossil for example from Strongs Cave (Cook 1963), Mammoth Cave (Merrilees 1968) and Devils Lair (Lundelius 1960, Dortch and Merrilees 1972).

Because of the nature of the material (one molar) representing *Bettongia* sp. it has not been possible to determine which of the two living species known from south-western Australia is represented in the Cave 3 material. *Bettongia penicillata* has been collected live from the Cape Leeuwin-Cape Naturaliste region (Shortridge 1910). Although it occurs in the Devils Lair deposit (Dortch and Merrilees 1972), it has not been reported from the Strongs Cave deposit and is probably not represented in the Pleistocene deposit in Mammoth Cave (see Merrilees 1968). *Bettongia lesueur* has neither been collected live from this region nor been recorded from the Mammoth Cave deposit (Merrilees 1968). It is, however, recorded from Devils Lair (Lundelius 1960, Dortch and Merrilees, 1972).

Nyctophilus timoriensis has not been recorded live from the Cape Leeuwin-Cape Naturaliste region. The closest record (M976) is from the Pemberton area. Cook (1963) records the species as a fossil from the Strongs Cave fauna.

Pseudomys albocinereus is not known as a modern population from the Cape Leeuwin-Cape Naturaliste region. The closest records are from near Fremantle (Shortridge 1936), and the Chorkerup-Narrikup area north of Albany (e.g. M1732, M3417). However, it is represented in the Devils Lair deposit (Lundelius 1960, Dortch and Merrilees 1972).

Pseudomys shortridgei has not been collected live from the Cape Leeuwin-Cape Naturaliste region and is poorly known as a modern population in Western Australia. On the other hand it is generally abundant in prehistoric faunas from the west coast (e.g. Lundelius 1957), and the south coast at least as far east as Bremer Bay (Butler and Merrilees 1971). It is also known from the Devils Lair deposit (Lundelius 1960, Dortch and Merrilees 1972).

Pseudomys praeconis is another species not known as a living animal from the Cape Leeuwin-Cape Naturaliste region, and indeed it has been regarded as confined to the Shark Bay region (see, for instance, Ride 1970). Lundelius (1957) reported *P. nanus* from Lake Cave. As shown above, this record probably represents *P. praeconis.* A single specimen is also listed by Dortch and Merrilees (1972) from Devils Lair. The importance of the records lies in the recognition of this species in the extreme south-west, indicating a much wider former distribution. A substantial reduction in range of true *P. nanus* is also implied, casting doubt on the extension of range suggested by Lundelius (1957).

Rattus fuscipes is still very common in coastal habitats of south-western Australia, and is well represented by specimens in the Western Australian Museum. Four (M8351-8354) were trapped by M. Archer and others along Turner Brook near Cave 1. This species is also generally well represented by specimens from the surface of many cave deposits in the Cape Leeuwin-Cape Naturaliste region. Lundelius (1960) recorded *R. fuscipes* as the only species of *Rattus* in the Devils Lair deposit, and it was the only representative of the genus obtained from the same deposit by Dortch and Merrilees (1972). Lundelius (1960) also lists this species from the Mammoth Cave deposit, but the specimen(s) on which he based this record are not designated. There are two *Rattus* specimens (65.4.39-40) from the Mammoth Cave deposit in the Western Australian Museum; both are considered to represent *R. fuscipes* on the criteria used here.

Rattus tunneyi (Fig. 2) is not known as a living animal from the Cape Leeuwin-Cape Naturaliste region, the closest record being that listed by Mahoney (1969) from "Perth—lakes". It was originally described from northern Australia and for many years was only known from that part of the continent. The species is apparently absent from the Devils Lair deposit, but is known from the surface of deposits in four other caves in the Cape Leeuwin-Cape Naturaliste region: 70.6.87 from a cave near Mammoth Cave, 70.7.199 from Skull Cave, 71.6.26 from Yallingup Cave, and 72.2.1 from the Brides Cave doline.

Hydromys chrysogaster is distributed in river systems of south-western Australia. Although live specimens were not reported from the Cape Leeuwin-Cape Naturaliste region by Shortridge (1936), the Western Australian Museum collections include modern specimens (M6576, M6580, M6581) from the stream system which flows through Mammoth Cave, and fossil specimens (e.g. 68.4.188) from a small number of caves in the same region.

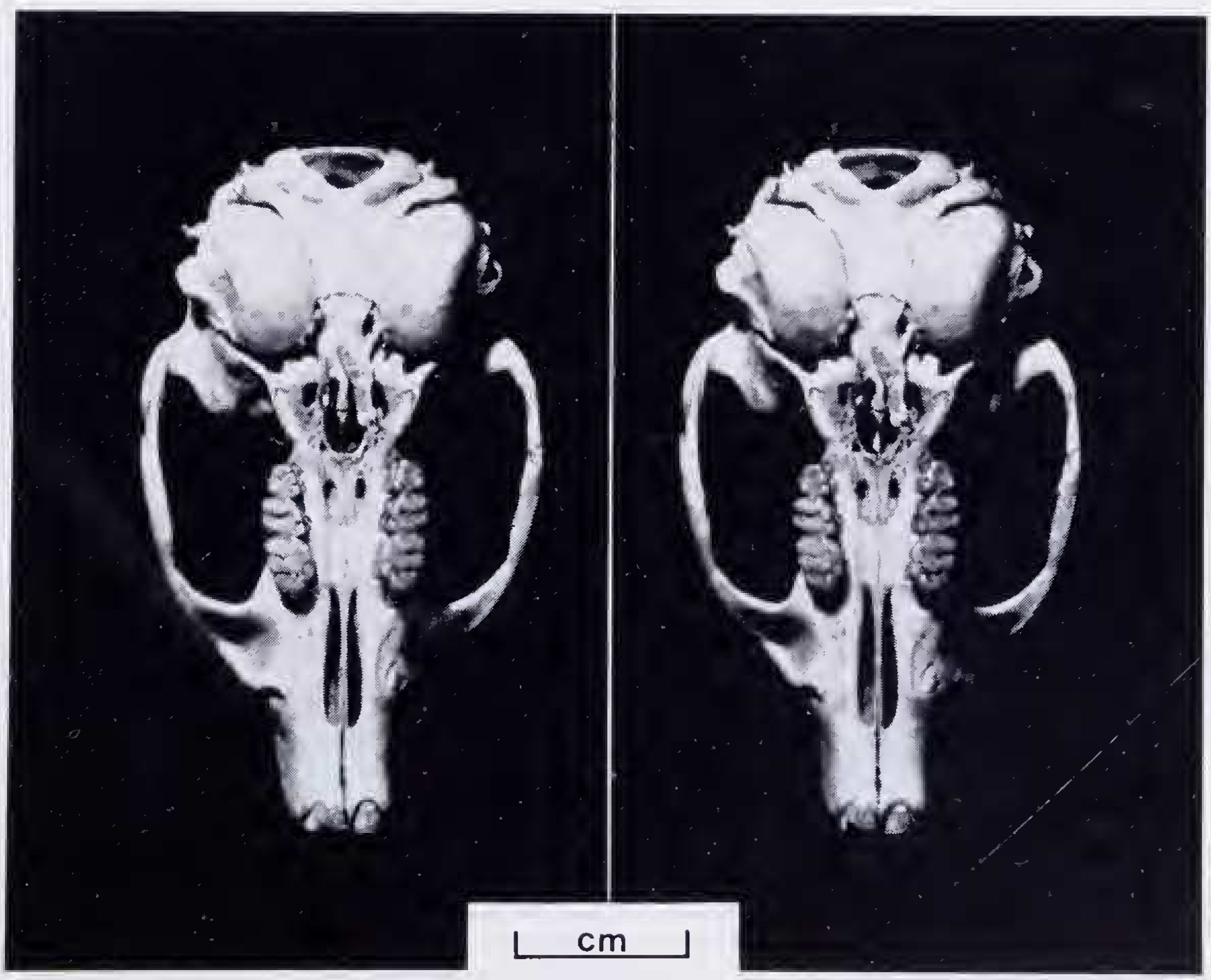

Figure 2.—Stereo-pair of ventral view of skull of *Rattus tunneyi* (71.11.224) from Cave 1. The very large bullae characteristic of this species are easily seen. This very well preserved specimen is one of many from the deposit.

Age of Deposits

Lundelius (1960) reports two radiocarbon dates for Devils Lair (= Nannup Cave of Lundelius, see Merrilees 1968): 8500 ± 160 years B.P. for material collected from immediately under the travertine floor which covered the excavation site and 12175 ± 275 years B.P. for a sample collected from a depth of four feet. Dortch and Merrilees (1972) describe further studies in Devils Lair and report on faunal remains between and below the dated levels of Lundelius (1960). Lundelius (1960) also reports a radiocarbon date of greater than 37000 years B.P. for a sample of charcoal taken from the excavation site in Mammoth Cave. Merrilees (1968) reports a date greater than 31500 years B.P. for a smaller amount of charcoal collected from the same excavation site.

Hair (49 gms) from the mammals represented throughout the 8 cm interval excavated from the Cave 1 deposit was submitted for radiocarbon dating. The result of the assay (GaK-2949) was a date of 430 ± 160 years B.P. No material suitable for radiocarbon dating was recovered from the Cave 3 deposit.

The only other evidence available, on the relative ages of the Cave 1 and Cave 3 deposits, and for defining the periods over which they accumulated, is from the contained faunas. In neither are there remains of any introduced mammal species. *Mus musculus*, *Rattus rattus*, and *Oryctolagus cuniculus* are all represented by specimens (e.g. 68.4.12, 72.3.21, 65.12.295 respectively) from other cave deposits in the Cape Leeuwin-Cape Naturaliste region. Further, M. and E. Archer trapped *Rattus rattus* (M8355) along Turner Brook near Cave 1. It therefore seems likely that accumulation in both caves ceased before any of these species reached the Turner Brook area. Shortridge (1936) states that *Mus musculus* and *Rattus rattus* were collected at Margaret River between 1904 and 1907. Rabbits probably arrived later. Shortridge (in Thomas 1907) notes that they had not reached the south-west of Australia when he was collecting in the area.

The Cave 3 fauna includes *Pseudomys albocinereus*, but it is absent from Cave 1 (discussed below). This species was recovered from each interval of the excavation made in Devils Lair by Dortch and Merrilees (1972). It therefore appears to have been established in the area for a long period of time. This suggests that accumulation may have begun earlier in Cave 3 than in Cave 1, and that *P. albocinereus* may have become locally extinct between these two events.

Discussion

Agents of Accumulation

The preponderance of small mammals in both faunas, and the relatively undamaged state of the skulls of many of the specimens (see Fig. 2) suggests that owls were the predators responsible for the accumulation of mammal remains in Cave 1 and Cave 3. Further support for this interpretation is provided by the occurrence in the Cave 1 deposit of skull and dentaries of single individuals in small discrete masses which may represent partially decomposed owl pellets (e.g. *Antechinus flavipes* 71.11.273). Teeth of *Sarcophilus harrisii* were found in another south-western cave deposit (Kangeroo Pot) in-

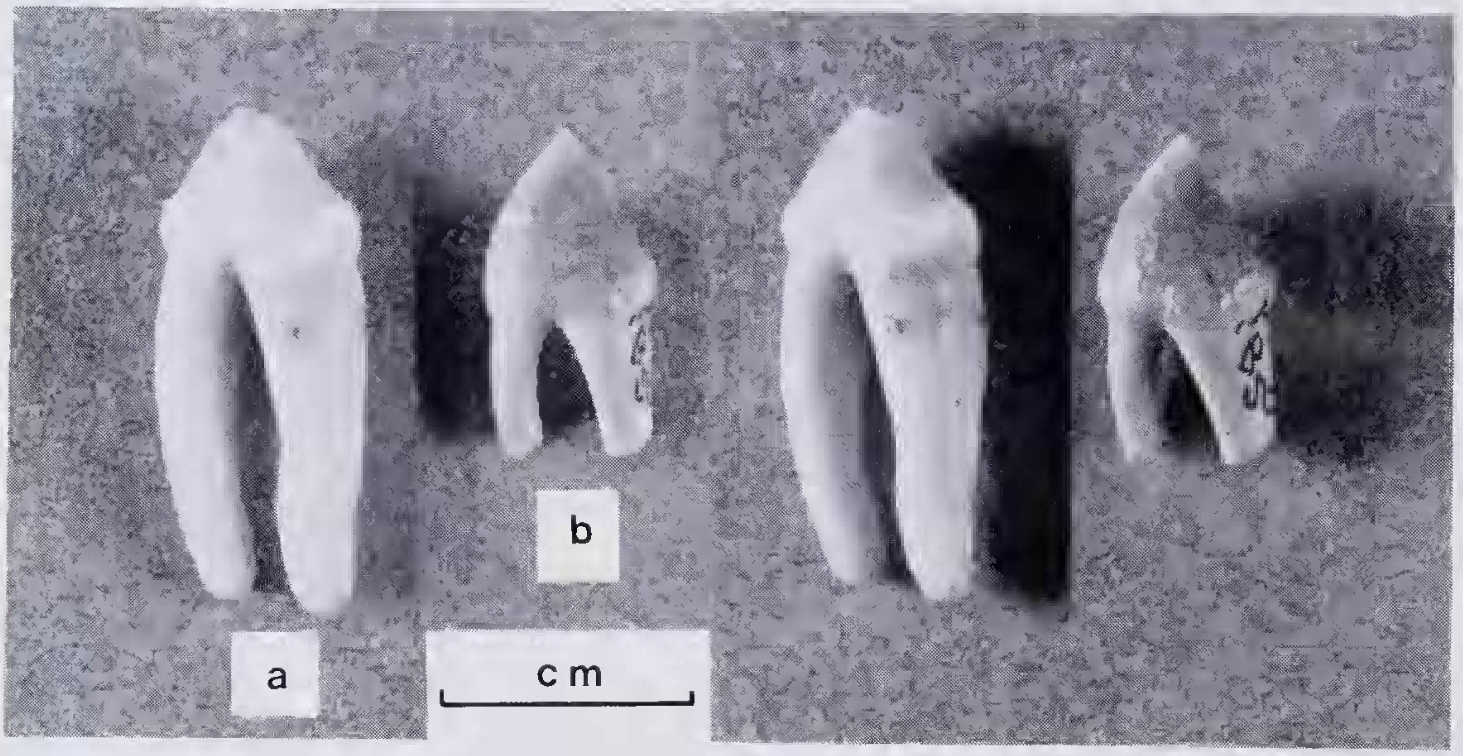

Figure 3.—(a) Stereo-pair of an upper third right premolar of an adult specimen (M6556) of *Sarcophilus harrisii*. (b) Stereo-pair of the upper third right premolar (71.11.285) of *Sarcophilus harrisii* from Cave 1. The much shorter open-ended roots of the Cave 1 specimen indicate that it represents a juvenile individual.

vestigated by one of us (Archer, yet to be published), which is also interpreted as an owl pellet deposit. In both cases the *Sarcophilus* teeth are unworn and have poorly formed roots (Fig. 3). They were almost certainly unerupted and would represent pouch-young individuals within the size range of prey normally taken by large owls. Although it is possible that a mammalian carnivore contributed part of the Cave 1 or Cave 3 deposits including the juvenile individual of *Sarcophilus harrisii*, there are no broken or chewed bones, coprolites, or other evidence normally considered to suggest the activities of a mammalian carnivore (see Lundelius 1966) in either deposit. In addition the relatively inaccessible situation of Cave 3 would make any but bird predators unlikely there.

The total number of individuals recorded in the fauna from Cave 3 (107) is only about one sixth that of Cave 1 (653), yet the number of species from Cave 3 (16) is slightly higher than from Cave 1 (13). This greater diversity is principally due to the inclusion in the Cave 3 deposit of single specimens of larger mammal species typical of south-western faunas. It seems probable that the differences in the faunas reflect the presence of different or additional owl predators in Cave 3. Not only the widespread medium-sized owl species, *Tyto alba* and *Ninox novaeseelandiae*, but also the much larger *T. novaehollandiae* and *N. connivens* are found in the extreme south-west of Australia (Serventy and Whittell 1967). Either of the last two could be powerful enough to prey upon all the mammal species included in the fauna from Cave 3.

Since the greater diversity of prey species is found in the smaller deposit, Cave 3, it is reasonable to assume that the owl predators which accumulated the fauna in the larger deposit, Cave 1, adequately sampled the small mammal species occurring in the area. It follows that the absence of *Pseudomys albocinereus* from Cave 1 reflects a genuine absence from the contemporary fauna.

Species records of significance

Sarcophilus harrisii has been recorded live from the Australian mainland only twice, in 1912 at Tooborac sixty miles from Melbourne, and in 1971 near Ballarat (noted in *The West Australian* for 25 May, 1971). Ride (1970) suggests that, although it is commonly thought that the Tooborac animal had escaped from captivity, there is no certainty that this was the case. The same comment could also apply to the specimen captured near Ballarat. *Sarcophilus harrisii* has been reported from fossil bone deposits in Victoria (e.g. Gill 1955), South Australia (e.g. Wakefield 1964), Northern Territory (Calaby and White 1967) and Western Australia (e.g. Merrilees 1968). Gill (1955) reports a radiocarbon date of 538 ± 200 years B.P. for *Sarcophilus harrissi* from the Tower Hill Beach locality of western Victoria. However, Gill (1971) more recently considers that this association is erroneous and that ". . . the *Sarcophilus* is about 5,000 years old at this site". Lundelius (1960) reports that the species is represented on the Swan coastal plain of Western Australia in the Wedges Cave deposit from a level which is dated at 3750 ± 240 years B.P. Calaby and White (1967) consider the Northern Territory record of *Sarcophilus harrisii* to be not older than 3,120 years. This was previously the youngest record from the Australian mainland.

The specimens of *Sarcophilus harrisii* (noted above) from the Kangaroo Pot deposit which has been dated at 620 ±90 years B.P. (GaK-3477) add weight to the evidence from Cave 1 that the species survived until late Recent time in south-western Australia. In view of the date of 430 ± 160 years B.P. (GaK-2949) reported here for Cave 1, *Sarcophilus harrisii* might even have been living in the south-west of Australia at the time of European settlement.

Three of the taxa represented in the Cave 1 and Cave 3 faunas are not recorded in the Devils Lair fauna by Dortch and Merrilees (1972). *Nyctophilus timoriensis*, like most bat species, is poorly represented in Western Australian cave deposit faunas, so the significance of the record cannot be assessed. *Hydromys chrysogaster* is another species not often found in cave deposits. The lack of a record from older deposits might indicate a recent arrival in the area, but it seems much more probable that it has simply not been sampled by predators contributing to cave deposit faunas. On the other hand, the absence of *Rattus tunneyi* from older faunas is considered meaningful. It is possible that the species was present in the Cape Leeuwin-Cape Naturaliste region at the time of accumulation of the Devils Lair deposit, but because of its restriction to a coastal heath habitat some distance from the cave, was not sampled by the owl predators. However the fauna obtained from the deposit by Dortch and Merrilees (1972) includes other species which are characteristic of drier heath habitats. The absence of *R. tunneyi* from the deposit therefore probably indicates genuine absence from the area at the time of accumulation of the Devils Lair deposit. Its presence in Cave 1 and Cave 3, and only on the surface in other caves in the Cape Leeuwin-Cape Naturaliste region, would suggest a late invasion (or perhaps re-invasion) of the area. To place this hypothesis on a really sound footing evidence of appearance in a dated stratified deposit is necessary. Data of this type are also needed before an attempt can be made to correlate time of arrival with past climatic changes interpreted from independent evidence, such as that used by Churchill (1968).

Serventy and Whittell (1967) postulate that the Eyrean bird species found in the coastal regions of the extreme south-west of Australia reached these localities via western and southern corridors of heath communities. These exist between the coasts and the forest block which they consider forms a barrier to movement of such birds. The habitats occupied by *Rattus tunneyi* range from open woodland to coastal sand dunes (Ride 1970), but are not known to include sclerophyll forest. It therefore seems likely that this rat reached the Cape Leeuwin-Cape Naturaliste region via one (or both) of these coastal heath corridors.

Rattus tunneyi is abundant as a member of cave faunas from Yanchep to Dongara, and is present through the full depth of the deposit in Hastings Cave, which spans from at least 11,000 years ago to the present (A. Baynes unpublished observations). It thus appears to have been established throughout a long period of time as a member of the fauna of the Swan coastal plain. There are abundant remains (e.g. 71.1.413) of this species among material from a surface site at the mouth of the Donnelly River (at approximately lat. 34° 29′ S, long. 115° 41′ E), and there is a single specimen (71.2.24) from a cave at Windy Harbour (at approximately lat. 34° 50′ S, long. 116° 0′ E). However, there is no evidence that the species has occurred further east than this on the south coast either in historic or prehistoric times. It was not obtained by the early collectors working north from King George's Sound (but was collected at about the same time on the Victoria Plains—see Mahoney 1969). It was also not in a prehistoric fauna collected by Butler and Merrilees (1971) at Bremer Bay, which was radiocarbon dated using bone at 1190 ± 80 years B.P. It is therefore more probable that the species reached the Cape Leeuwin area from the Swan coastal plain population via the western corridor. From there it may have continued on to the south coast.

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References

Bain, T. (1962).—The geomorphology of the Cape Hamelin coastal limestones and sand dunes. *Journal of the Western Australian Speleological Group* 1962: 18-28.

Butler, W. H. and Merrilees, D. (1971).—Remains of *Potorous platyops* (Marsupialia, Macropodidae) and other mammals from Bremer Bay, Western Australia. *Journal of the Royal Society of Western Australia* 54: 53-58.

Calaby, J. H. and White, C. (1967).—The Tasmanian Devil *(Sarcophilus harrisi)* in Northern Australia in Recent times. *The Australian Journal of Science* 29: 473-475.

Churchill, D. M. (1968).—The distribution and prehistory of *Eucalyptus diversicolor* F. Muell., *E. marginata* Donn ex Sm., and *E. calophylla* R. Br. in relation to rainfall. *Australian Journal of Botany* 16: 125-151.

Cook, D. L. (1960).—Some mammal remains found in caves near Margaret River. *The Western Australian Naturalist* 7: 107-108.

Cook, D. L. (1963).—The fossil vertebrate fauna of Strong's Cave, Boranup, Western Australia. *The Western Australian Naturalist* 8: 153-162.

Dortch, C. E. and Merrilees, D. (1972).—A salvage excavation in Devil's Lair, Western Australia. *Journal of the Royal Society of Western Australia* 54: 103-113.

Gill, E. D. (1955).—Aboriginal midden sites in western Victoria dated by radiocarbon analysis. *Mankind* 5: 51-5.

Gill, E. D. (1971).—The Australian Aborigines and the Tasmanian Devil. *Mankind* 8: 59-63.

Glauert, L. (1948).—The cave fossils of the south-west. *The Western Australian Naturalist* 1: 101-104.

Jennings, J. N. (1968).—Syngenetic karst in Australia. pp. 41-110 in *Contributions to the study of karst* by P. W. Williams and J. N. Jennings. Canberra: Australian National University Geography Publication G/5.

Lundelius, E. L. (1957).—Additions to knowledge of ranges of Western Australian mammals. *The Western Australian Naturalist* 5: 173-182.

Lundelius, E. L. (1960).—Post Pleistocene faunal succession in Western Australia and its climatic interpretation. *Report of the International Geological Congress, XXI Session, Norden 1960*. Pt. IV Chronology and Climatology of the Quaternary: 142-153.

Lundelius, E. L. (1963).—Vertebrate remains from the Nullarbor Caves, Western Australia. *Journal of the Royal Society of Western Australia* 46: 75-80.

Lundelius, E. L. (1964).—Notes on the skulls of two Australian rodents with a key to the skulls of the rodents of south-western Australia. *Journal of the Royal Society of Western Australia* 47: 65-71.

Lundelius, E. L. (1966).—Marsupial carnivore dens in Australian caves. *Studies in Speleology* 1: 174-180.

Mahoney, J. A. (1969).—A re-identification of the Australian Muridae in the Leiden Museum listed by F. A. Jentink in 1887 and 1888. *Zoologische Mededelingen* 43: 279-286.

Merrilees, D. (1968).—Man the destroyer: late Quarternary changes in the Australian marsupial fauna. *Journal of the Royal Society of Western Australia* 51: 1-24.

Merrilees, D. (1969).—A newly discovered bone-bearing deposit in Labyrinth Cave, near Augusta, Western Australia. *The Western Australian Naturalist* 11: 86-87.

Ride, W. D. L. (1970).—*A guide to the native mammals of Australia*. Melbourne: Oxford University Press.

Serventy, D. L. and Whittell, H. M. (1967).—*Birds of Western Australia*. 4th ed. Perth: Lamb Publications.

Shortridge, G. C. (1910).—An account of the geographical distribution of the marsupials and monotremes of south-west Australia, having special reference to the specimens collected during the Balston Expedition of 1904-1907. *Proceedings of the Zoological Society of London* **1909**: 803-848.

Shortridge, G. C. (1936).—Field notes (hitherto unpublished) on Western Australian mammals south of the Tropic of Capricorn (exclusive of Marsupialia and Monotremata), and records of specimens collected during the Balston Expeditions (November 1904 to June, 1907). *Proceedings of the Zoological Society of London* **1936**: 743-749.

Thomas, O. (1907).—List of further collections of mammals from Western Australia, including a series from Bernier Island, obtained for Mr. W. E. Balston; with field-notes by the collector, Mr. G. C. Shortridge. *Proceedings of the Zoological Society of London* **1906**: 763-777.

Wakefield, N. A. (1964).—Mammal remains. Pp. 494-498 in "Archaelogical excavation of Rock Shelter No. 6 Fromm's Landing, South Australia" by D. J. Mulvaney, G. H. Lawton and C. R. Twidale. *Proceedings of the Royal Society of Victoria* 77: 479-516.